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THE STARS: A STUDY OF THE UNIVERSE. BY PROFESSOR SIMON NEWCOMB.—A REVIEW.

By W. W. Campbell.

Centuries ago the starlike points that we see in the sky were classified as planets (wanderers) and fixed stars. Modern observations have shown that the term fixed is a misnomer: that the stars are in reality moving more rapidly, on the average, than the planets. Professor **Newcomb** has appropriately chosen the simple title of "The Stars" for his most interesting and suggestive book.

The study of the stars resolves itself into the consideration of two great subjects,—perhaps the greatest subjects in the whole realm of pure knowledge, viz.:—

I. *The Structure of the Universe.*
II. *The History of the Universe.*

All the researches of the astronomers of the past and present are but minor contributions to the solution of these main problems. Professor **Newcomb's** book touches lightly upon the second subject—indeed the present-day data are entirely too meager to warrant its serious consideration;—but he has entered boldly upon a determination of the Structure of the Universe. He has written excellent chapters on the cataloguing, the photometry, the motions, the parallaxes of the stars; and the seven concluding chapters, combining the results in the various departments of investigation in an effort to solve the main problem, are of surpassing interest. The scope of the book will be realized best from the following extract (Chapter XIV):—

> "First, we may inquire as to the extent of the universe of stars. Are the latter scattered through infinite space, so that those we see are merely that portion of an infinite collection which happens to be within reach of our telescopes, or are all the stars contained within a certain limited space? In the latter case, have our telescopes yet penetrated to the boundary in any direction? In other words, as, by the aid of increasing telescopic power, we see fainter and fainter stars, are those fainter stars at greater distances than those before known, or are they smaller stars, contained within the same limits as those we already know? Otherwise stated, do we see stars on the boundary of the universe?
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> "Secondly, granting the universe to be finite, what is the arrangement of the stars in space? Especially, what is the relation of the galaxy to

the other stars? In what sense, if any, can the stars be said to form a permanent system? Do the stars which form the Milky Way belong to a different system from the other stars, or are the latter a part of one universal system.

"Thirdly, what is the duration of the universe in time? Is it fitted to last forever in its present form, or does it contain within itself the seeds of dissolution? Must it, in the course of time, in we know not how many millions of ages, be transformed into something very different from what it now is? This question is intimately associated with the question whether the stars form a system. If they do, we may suppose that system to be permanent in its general features; if not, we must look further for our conclusion."

In considering these questions, NEWCOMB has taken the view of modern science that "no answer is valid unless based on careful observation." The facts of observation described in the preceding chapters are made to bear with excellent judgment and great skill. The valuable but more limited investigations by SEELIGER, KAPTEYN, SCHIAPARELLI, and others are utilized — due credit being given. It is impossible to describe in a short article the methods of solution followed; the hundred pages of the book devoted to their consideration cannot be condensed, but must be read as a whole.

A few of the many conclusions arrived at are as follows:—

1. If we consider as of unit volume the sphere whose radius is 200,000 times the Earth's distance from the Sun, we may say that there is one star on the average for eight units of volume.

2. That collection of stars which we call the universe is limited in extent. . . . This does not preclude the possibility that far outside of *our* universe there may be other collections of stars of which we know nothing.

3. The boundary of our universe is probably somewhat indefinite and irregular. As we approach it the stars may thin out gradually. The parallax at the boundary is probably no where greater than 0″.001, and may be much less. The time required for light to pass over the corresponding interval is more than 3,000 years.

4. The universe extends further around the girdle of the Milky Way than towards the poles of that girdle.

5. The total number of the stars is to be counted by the hundreds of millions.

The work, as a whole, contains a vast amount of information, stated philosophically and in a manner adapted to the needs of the working astronomer, as well as to the comprehension of the general reader. The author's greater experience along mathematical lines is the satisfactory explanation for a weakness here and there in the astrophysical chapters. As a case in point, the latter part of page 188, on the spectra of the nebulæ, should be rewritten for subsequent editions. The strong chapters are those in which the author has used the statistical method, and it is fortunate that his ripe judgment was brought to bear upon these difficult problems.